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(71) Applicant: SHINKO KOSEN KOGYO KABUSHIKI KAISHA also known as SHINKO WIRE CO. LTD.
2 Doi-cho 7 chome
Amagasaki 660(JP)

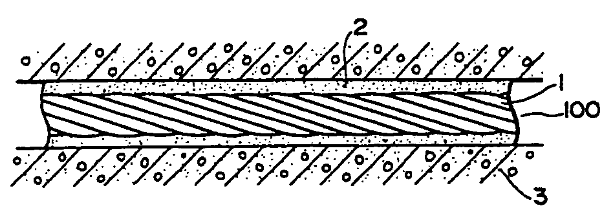
(72) Inventor: Kurauchi, Makoto
2 Doi-cho 7-chome
Amagasaki-shi, Hyogo-ken(JP)
Inventor: Hayasaki, Kiyoshi
2 Doi-cho 7-chome
Amagasaki-shi, Hyogo-ken(JP)
Inventor: Minami, Toshikazu
2 Doi-cho 7-chome
Amagasaki-shi, Hyogo-ken(JP)
Inventor: Ohnishi, Mutsuhiko
2 Doi-cho 7-chome
Amagasaki-shi, Hyogo-ken(JP)

(74) Representative: Charlton, Peter John et al
Elkington and Fife High Holborn House 52/54
High Holborn
London WC1V 6SH(GB)

(54) Tendons for prestressed concrete structure and method of using such tendons.

(57) A tendon (100) for prestressed concrete structure (3) comprises a core member (1) such as a steel wire for prestressed concrete structures, a steel strand for prestressed concrete structures or a steel bar for prestressed concrete structures, and an unset bonding material (2) coating the core structure (1) in a predetermined thickness, having a specific setting time determined by selectively determining the respective contents of the ingredient of the bonding material and capable of setting at an ordinary temperature. The tendon (100) is arranged in a desired arrangement for forming a prestressed concrete structure, concrete is placed so as to bury the tendons therein, and then the tendons (100) are tensioned and fixed after the strength of the deposited concrete has increased to a degree to permit tensioning the tendons and before the unset bonding material sets. Thus, the unset bonding material sets after the tendons have been tensioned and fixed to bond the tendons firmly to the prestressed concrete structure.

FIG. 1



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TENDONS FOR PRESTRESSED CONCRETE STRUCTURES AND METHOD OF USING SUCH TENDONS

The present invention relates to tendons for posttensioned prestressed concrete structures, which can perfectly be prevented from corrosion without requiring grouting, can integrally be incorporated into prestressed concrete structures after being tensioned, and can easily be used for prestressing concrete structures, and a method of using such tendons.

In the conventional posttensioning process for forming a prestressed concrete structure, sheaths are arranged prior to the placement of concrete, prestressing steels such as steel bars, wires or strands are inserted in the sheaths after or before the concrete has set, and then the prestressing steels are tensioned when the concrete reaches to the desired strength. Then, a cement milk or the like is injected under pressure into the sheaths for corrosion prevention and for integrally bonding the prestressing steels to the concrete structure. The insertion of the prestressing steels into the sheaths and the injection of the cement milk or the like are very complicated work requiring a long time and much labor and increasing the cost of prestressed concrete structures. Furthermore, since, in most cases, the prestressing tendon is arranged in curvature, it is difficult to fill up the sheaths perfectly with the cement milk or the like, and hence it is possible that the prestressing steels in unfilled portions of the sheaths are corroded.

A method of eliminating such disadvantages of the conventional posttensioning process is proposed, for example, in Japanese Patent Publication No. 53-47609, in which a prestressing member is formed by coating a steel material with a grease and encasing the steel material coated with the grease in a plastic case. This method prevents the corrosion of the prestressing steel perfectly by the grease or the like and makes the injection of a cement milk or the like unnecessary. However, the prestressing steel remains not bonded to the concrete structure after the same has been tensioned. Accordingly, when the prestressing tendon is overloaded temporarily, load is concentrated on the fixed portions of the prestressing tendon to break the prestressing steel at the fixed portions. Since the prestressing steel is not bonded to the concrete structure, the breakage of the prestressing steel, even at a single point thereon, affects the strength of the prestressed concrete structure entirely. Furthermore, the ultimate bending strength of a prestressed concrete structure having unbonded prestressing tendon is lower than that of an equivalent prestressed concrete structure having bonded prestressing tendon.

The present invention has been made to eliminate the drawbacks of the conventional prestressing tendon.

Accordingly, it is an object of the present invention to provide tendons for prestressed concrete structures, comprising a core member, capable of perfectly preventing the corrosion of the core member, capable of firmly adhering to concrete and not having weakness at the fixed portions thereof.

It is another object of the present invention to provide a method of using such tendons.

According to a first aspect of the present invention, a tendon comprises a core member for prestressing a concrete structure, such as a steel wire, a steel strand or a steel bar, and the core member for prestressing a concrete structure is coated with a film of 20 μ or above in thickness of an unset bonding material having a setting time adjusted so that the unset bonding material does not set before the core member is tensioned and sets at an ordinary temperature after the core member has been tensioned and the tendon has been fixed to the concrete structure.

According to a second aspect of the present invention, a tendon comprises a core member for prestressing a concrete structure, such as a steel wire, a steel strand or a steel bar, the core member for prestressing a concrete structure is coated with a film of 20 μ or above in thickness of an unset bonding material having a setting time adjusted so that the unset bonding material does not set before the core structure is tensioned and sets at an ordinary temperature after the core structure has been tensioned and the tendon has been fixed to the concrete structure, and the core member coated with such an unset bonding material is encased in a sheath to facilitate handling.

According to a third aspect of the present invention, a tendon comprises a core member for prestressing a concrete structure, such as a steel wire, a steel strand or a steel bar, the core structure is coated with an unset bonding material, and the adhesion of the core structure is increased after the bonding material has set.

According to a fourth aspect of the present invention, tendons each comprising a core member for prestressing a concrete structure, such as a steel wire, a steel strand or a steel bar, coated with a film of 20 μ or above in thickness of an unset bonding material having a setting time adjusted so that the unset bonding material does not set before the core member is tensioned and sets at an ordinary temperature after the core member has been tensioned and the tendon has been fixed to the concrete structure are arranged in a predetermined arrangement, concrete is placed, and then

the core members are tensioned before the bonding material sets, after the strength of the deposited concrete has increased to a predetermined degree.

According to a fifth aspect of the present invention, tendons each comprising a core member for prestressing a concrete structure, such as a steel wire, a steel strand or a steel rod, coated with a film of 20 μ or above in thickness of an unset bonding material having a setting time adjusted so that the bonding material does not set before the core structure is tensioned and sets at an ordinary temperature after the core structure has been tensioned and the tendon has been fixed to the concrete structure, and encased in a sheath are arranged in a predetermined arrangement, concrete is placed, and then the core member are tensioned before the bonding material sets, after the strength of the concrete has increased to a predetermined degree.

Thus, according to the present invention, the setting time of the unset bonding material coating the core member is adjusted so that the bonding material will not set before the tendon is tensioned and will set at an ordinary temperature after the tendon has been tensioned and fixed to the concrete structure, because the uniform propagation of a tensile force applied to the tendon through the entire length of the tendon is obstructed by the adhesion of the tendon to the concrete structure if the bonding material sets before the application of a tensile force to the tendon.

Generally, it takes approximately 170 hours after placement for the strength of concrete containing General-Use Cement to increase to a degree to permit tensioning tendons, and approximately 70 hours after placement for the strength of concrete containing High-Early-Strength Cement to increase to such a degree. Accordingly, a bonding material having a setting time adjustable to 70 hours or longer is used preferably for coating the core member and, more preferably, a bonding material having a setting time adjustable to 170 hours or longer is used for coating the core member. Since it is desirable that the bonding material coating the core member sets quickly after the core structure has been tensioned, it is preferable that the setting time is one year or less.

When the thickness of the film of the unset bonding material coating the core member is less than 20 μ, it is possible that pin holes are developed in the film to deteriorate the corrosion preventing effect of the film, and the film is unable to separate the core member satisfactorily from the concrete structure, so that the frictional resistance of concrete member to the movement of the core member during tensioning operation is increased. When the core member is a steel strand for prestressed concrete structure, the core surface of the core member cannot be coated by the bonding material in a uniform thickness. In such a case, the core structure is coated with the bonding material so that the thickness of the thinnest portion of the film is 20 μ or above.

There is no any particular restriction on the method of application of the bonding material provided that the core structure is coated with the bonding material in an appropriate thickness; the bonding material may be applied through any suitable coating process, for example, a brush coating process or a dip coating process.

Thus, an unset bonding material prepared so that it will not set before the core member is tensioned is applied to the core members of tendons, the tendons are arranged in a desired arrangement, concrete is placed, and then the core members are tensioned after the strength of the concrete has reached to a degree to permit tensioning the core members. Accordingly, the bonding material does not set before the core members are tensioned and hence the core members are not bonded to the concrete structure before the core members are tensioned, so that the core members can be tensioned uniformly over the entire length. After the core members have been tensioned, the bonding material sets gradually to bond the core members firmly to the concrete structure.

Thus, the present invention provides the following excellent effects.

(A) The core structures are coated with the bonding material at the place of manufacture, and hence work for arranging sheaths, inserting the core members into the sheaths and injecting a cement milk into the sheaths, which has been performed in the conventional posttensioning process, is not necessary, so that labor necessary for forming a prestressed concrete structure and the cost of the prestressed concrete structure are reduced remarkably.

(B) The bonding material coating the core members sets gradually by chemical reaction without requiring any artificial process such as heating, so that neither labor nor apparatus is necessary for setting the bonding material and any dangerous work is not required for forming a prestressed concrete structure.

(C) The core members are coated perfectly with the bonding material and the bonding material sets after the core members have been tensioned, so that the core members are prevented perfectly from corrosion.

(D) The bonding material sets to bond the core members firmly to the concrete structure, which improves the drawbacks of the unbonded core members incorporated into the concrete structure.

(E) The core members coated with the bonding material can be encased in sheaths, respectively, at the place of manufacture, so that the tendons can be manufactured under sufficient quality control and the corrosion of the core members attributable to the use of an inappropriate grout is prevented positively.

The above and other objects, features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings, in which:

Figure 1 is a fragmentary longitudinal sectional view of a tendon, in a preferred embodiment, according to the present invention;

Figure 2 is a fragmentary longitudinal sectional view of a tendon, in another embodiment, according to the present invention;

Figure 3 is a graph showing the variation of setting time with the content of a hardener;

Figure 4 is a graph showing the variation of the adhesive strength of the core members with the lapse of time after the tendons have been buried in concrete;

Figure 5 is a graph showing the relation between pull-out load and the amount of slip of tendons relative to a concrete cylinder;

Figure 6 is a graph showing the load-displacement curves of the concrete beams with both ends sustained.

Embodiment 1:

Referring to Fig. 1, a tendon 100, in a first embodiment, according to the present invention comprises a core member 1 and a bonding material 2 coating the core member 1 in a film of a thickness in the range of 0.5 to 1 mm. The core member 1 is a steel strand of 12.7 mm in diameter for prestressed concrete. The bonding material 2 is a mixture of an epoxy resin and 0.3 percent by weight of an amine hardener containing a setting accelerator, having a setting time of approximately six months. Although there is not any particular restriction on the type of the bonding material 2, preferably, the bonding material 2 is a bonding material containing, as a principal ingredient, an epoxy resin, a polyurethane resin or a polyester resin in the light of sufficient strength of adhesion to the steel core member 1 and the necessity of avoiding the corrosive action of the bonding material 2 on the steel core structure 1.

A plurality of the tendons 100 are arranged in a predetermined arrangement, and then concrete 3 is placed.

Referring to Fig. 3 showing the variation of the setting time of the bonding material 2 with the contents of the hardener, the setting time of the bonding material 2 can be adjusted to an optional time by selectively determining the content of the hardener.

The tendons 100 were arranged in a predetermined arrangement one month after the manufacture thereof and the concrete 3 was deposited. The tendons 100 thus placed in the concrete 3 were subjected to tensioning tests from a time two months after the manufacture thereof, in which the rate of reduction of tensile force applied to one end of each tendon 100 during propagation to the other end of the tendon 100 was measured.

The results of the tensioning tests are shown in Fig. 4, in which an area 8 represents the variation of the rate of loss of tensile force with the lapse of time with the tendons 100 of the present invention, and an area 7 represents the variation of the rate of loss of tensile force with the lapse of time with conventional unbonded tendons each comprising a steel strand for prestressed concrete subjected to the tensioning tests as controls. As obvious from Fig. 4, the rate of loss of tensile force applied to one end of the tendon 100 of the present invention remains at a low level substantially the same as that of the conventional unbonded tendon within six months after the manufacture. The rate of loss with the tendons 100 starts increasing from a time six months after the manufacture, which is inferred that the core members 1 of the tendons 100 are bonded firmly to the concrete 3 six months after the manufacture. Thus, the tendon 100 of the present invention can be tensioned satisfactorily within six months after the manufacture.

Although the setting time of the bonding material 2 of the second embodiment is adjusted to six months, the setting time of the bonding material 2 can be adjusted to an optional time by properly determining the contents of the ingredients thereof taking into consideration the time in which the strength of the concrete 3 increases to a value to permit tensioning the tendon.

The tendons 100 were subjected further to pull-out tests, in which pulling force was applied to the tendons 100 after the bonding material 2 had set and the slip of the tendons 100 relative to the concrete 3 was measured. Measured results are shown in Fig. 5, in which a curve 10 represents the relation between the pulling force applied to steel strands for prestressed concrete buried directly in concrete as controls and the average slip of the steel strands relative to the concrete, and a curve 11 represents the relation between the pulling force applied to the tendons 100 of the present invention and the average slip of the tendons 100 relative to the concrete 3.

As obvious from Fig. 5, the average maximum adhesive strength of 95.4 kg/cm², namely, a pulling

force to which the adhesive strength of the tendon yielded, of the tendon 100 of the present invention is far greater than the average maximum adhesive strength of 46.6 kg/cm² of the control.

Embodiment 2:

Referring to Fig. 2, showing a tendon 200, in a second embodiment, according to the present invention, the tendon 200 comprises a core member 1, which is similar to that of the first embodiment, a bonding material 2 coating the core member 1, and a corrugated sheath 4 encasing the core steel 1 coated with the bonding material 2 therein. A plurality of the tendons 200 are arranged in a predetermined arrangement, and then the concrete 3 is placed.

The bonding material 2 of the second embodiment is the same as that of the first embodiment. The setting time of the bonding material 2 is approximately six months.

The core member 1 is a steel strand of 12.7 mm in diameter for prestressed concrete. The core member 1 was dipped in the bonding material 2 to coat the core member 1 with the bonding material 2 in a thickness in the range of 0.5 to 1 mm.

Although the sheath 4 is formed of a polyethylene resin in this embodiment, the sheath 4 may be formed of any suitable resin or an ordinary metal such as a steel. The sheath 4 is corrugated to restrain the sheath 4 from axial movement relative to the concrete 3.

The tendons 200 were subjected to pull-out tests. Test procedures were the same as those taken for testing the adhesive strength of the tendons 100 of the first embodiment. The results of the pull-out tests are represented by a curve 12 in Fig. 5. The average maximum adhesive strength of the tendons 200 is 96.0 kg/cm², which is far greater than that of the conventional tendons.

The prestressed concrete test beams A incorporating the tendons 200, the prestressed concrete test beams B incorporating steel strands of 12.7 mm in diameter for prestressed concrete and fabricated through the ordinary pottensioning process and the cement grouting process, and the prestressed concrete test beams C incorporating unbonded steel strands for prestressed concrete were subjected to bending tests specified in JIS (Japanese Industrial Standards) A 1106. Test results are shown in Fig. 6, in which curves 13, 14 and 15 are load-displacement curves respectively. for the prestressed concrete test beams A, B and C. As obvious from Fig. 6, the prestressed concrete test beams A and B are substantially the same in bending strength and load-displacement characteristics, and the bending characteristics of the prestressed concrete test beam A are superior to those of the prestressed concrete test beams C.

Claims

1. A tendon for prestressed concrete structures, comprising: a core member; and an unset bonding material coating said core member in a predetermined thickness, having a specific setting time, and capable of setting at an ordinary temperature.

2. A tendon for prestressed concrete structures, as recited in claim 1, wherein said core member is a steel wire for prestressed concrete structures.

3. A tendon for prestressed concrete structures, as recited in claim 1, wherein said core member is a steel strand for prestressed concrete structures.

4. A tendon for prestressed concrete structures, as recited in claim 1, wherein said core member is a steel bar for prestressed concrete structures.

5. A tendon for prestressed concrete structures, as recited in any preceding claim, wherein said specific setting time of said unset bonding material can be adjusted by selectively determining the respective contents of the ingredients of said bonding material to a time longer than a time in which the strength of concrete in which said tendon is buried increases to a degree to permit tensioning said tendon.

6. A tendon for prestressed concrete structure, as recited in any preceding claim, wherein the thickness of said bonding material coating said core member is 20μ or above.

7. A tendon for prestressed concrete structures, as recited in any preceding claim, wherein said unset bonding material is an unset adhesive resin.

8. A tendon for prestressed concrete structures, as recited in claim 7, wherein said unset adhesive resin is an epoxy resin, a polyurethane resin, a polyester resin, etc.

9. A tendon for prestressed concrete structures, as recited in any preceding claim, further comprising a sheath encasing said core member coated with said unset bonding material.

10. A tendon for prestressed concrete structures, as recited in claim 9, wherein said sheath is a corrugated sheath.

11. A tendon for prestressed concrete structure, as recited in claim 9 or 10, wherein said sheath is formed of a steel.

12. A tendon for prestressing concrete structure, as recited in claim 9 or 10, wherein said sheath is formed of a resin.

13. A method of using tendons for prestressed concrete structure, each comprising: a core member; and an unset bonding material coating said core structure in a thickness of 20μ or above, having a specific setting time, and capable of setting at an ordinary temperature, said method comprising steps of: arranging said tendons in a desired arrangement; placing concrete so as to bury said tendons therein; and tensioning and fixing said tendons after the strength of the placed concrete has increased to a degree to permit tensioning said tendons and before said unset bonding material sets.

14. A method of using tendons for prestressed concrete structure, each comprising: a core member; an unset bonding material coating said core member in a thickness of 20μ or above, having a specific setting time, and capable of setting at an ordinary temperature; and a sheath encasing said core member coated with said unset bonding material therein, said method comprising steps of: arranging said tendons in a desired arrangement; depositing concrete so as to bury said tendons therein; and tensioning and fixing said tendons after the strength of the deposited concrete has increased to a degree to permit tensioning said tendons and before said unset bonding material sets.

FIG. 1

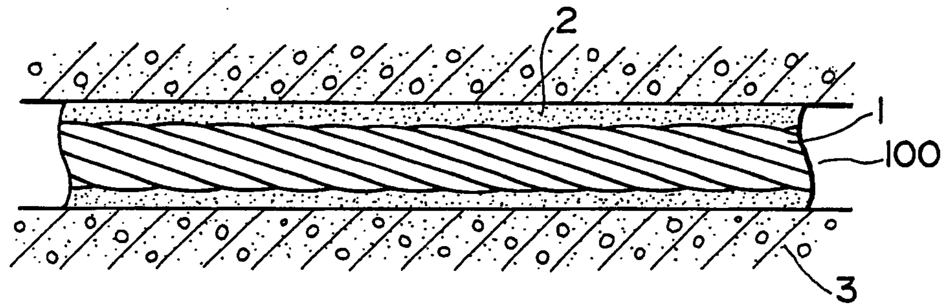


FIG. 2

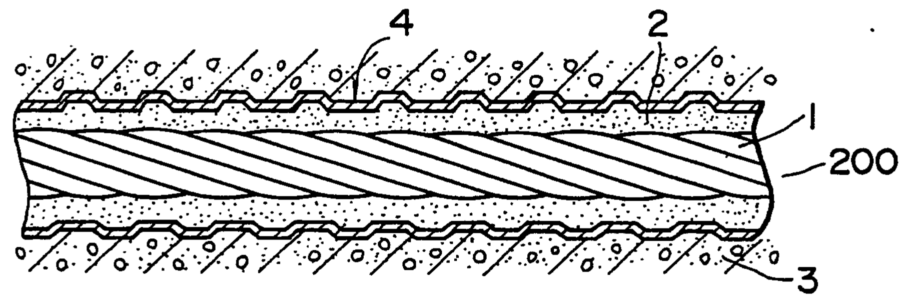


FIG. 3

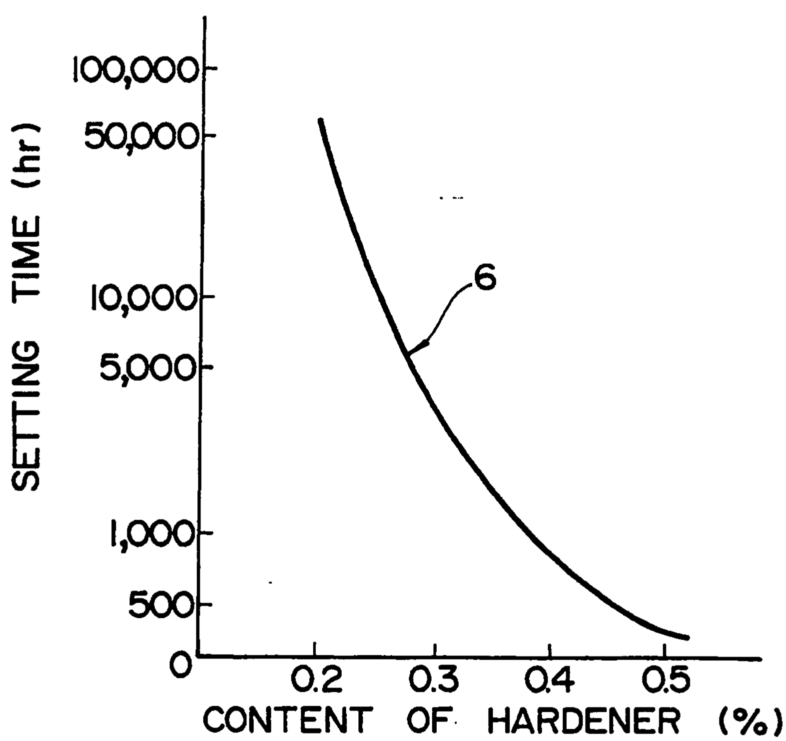


FIG. 4

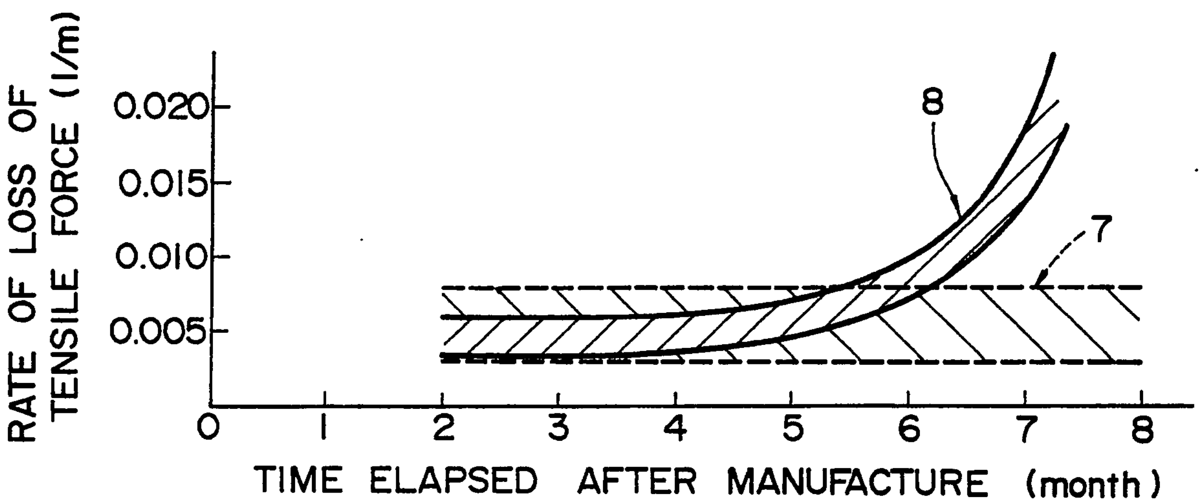

RATE OF LOSS OF TENSILE FORCE (l/m)
0.020
0.015
0.010
0.005
8
7
0
1
2
3
4
5
6
7
8
TIME ELAPSED AFTER MANUFACTURE (month)

FIG. 5

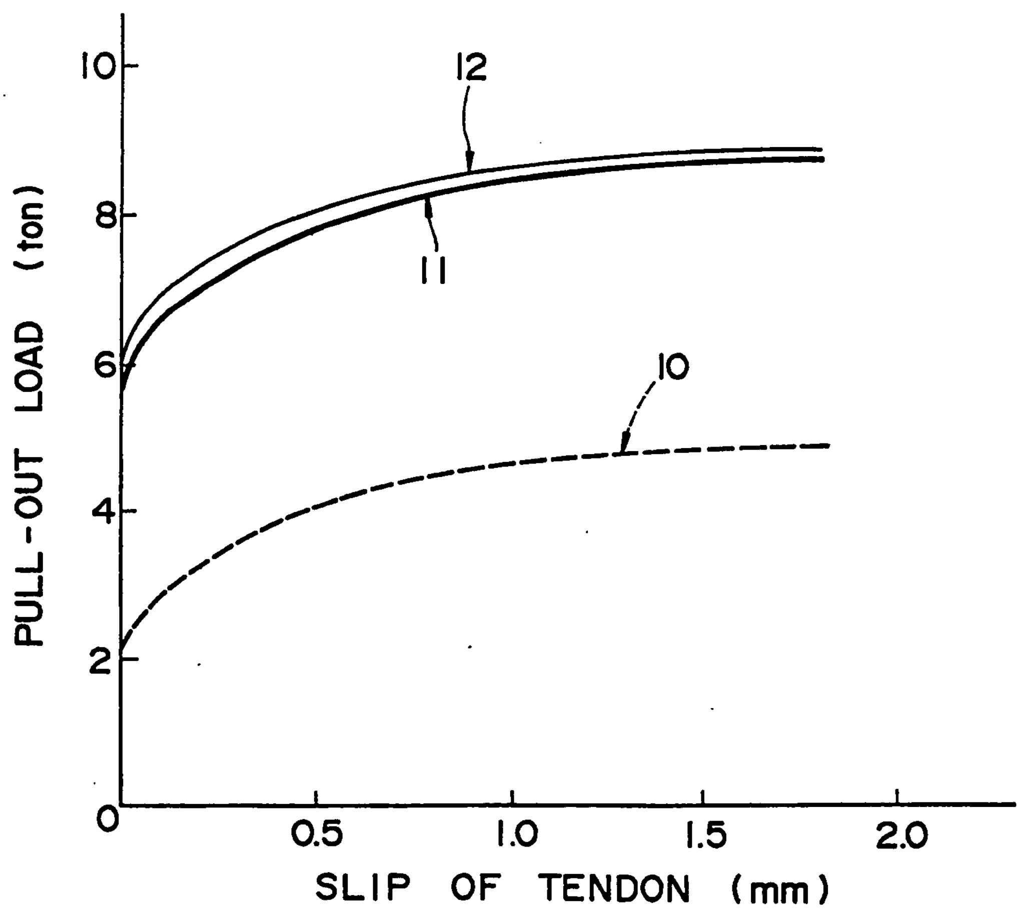
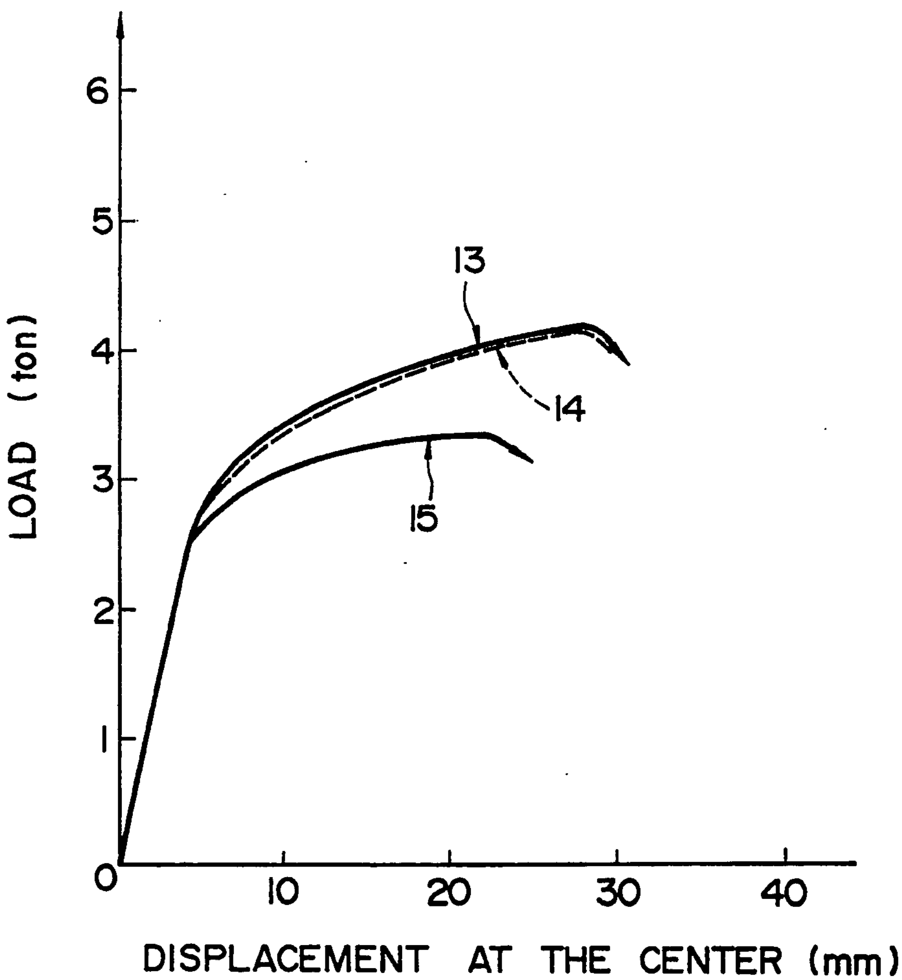

PULL-OUT LOAD (ton)
10
8
6
4
2
0
12
11
10
0.5
1.0
1.5
2.0
SLIP OF TENDON (mm)

FIG. 6


6
5
4
3
2
1
0
10
20
30
40
LOAD (ton)
DISPLACEMENT AT THE CENTER (mm)
13
14
15

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 87 31 0039

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	AT-B- 201 280 (BASF AG) * claims 1, 2; page 1, line 82 - page 2, line 45 *	1-4,7,8,13,14	E 04 C 5/08
A	---	5,6	
P,X	EP-A-0 219 894 (BEKAERT-COCKERILL) * figure 1; whole document * ---	1-10,13,14	
X	EP-A-0 129 976 (PSC FREYSSINET LTD.) * figure 2; claims 1-7 * ---	1-14	
A	DE-B-1 609 722 (F. LEONHARDT et al.) * claims 5-8 * -----	7,8	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

E 04 C 5/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	20-02-1988	BOUSQUET K.C.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document